2009
MASSACHUSETTS CLEAN TECHNOLOGY AWARDS

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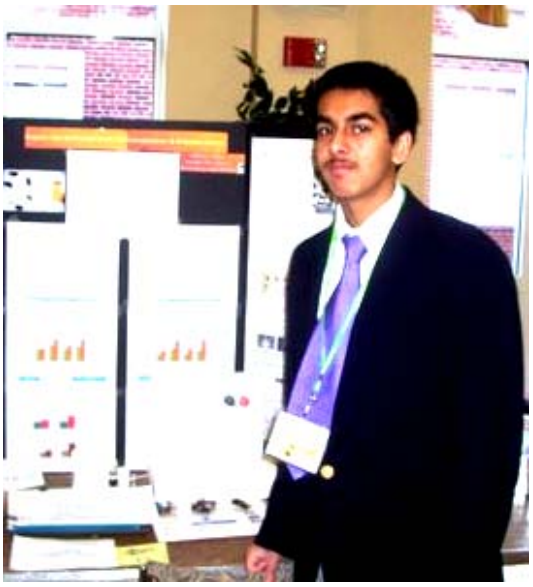

Region II, Central MA CleanTech, Honorable Mention:

Abhinav Mishra, Shrewsbury High School, Shrewsbury

"Organic Dye Sensitized Solar Cell: Development and Characterization"

ABOUT ME:

Abhinav Mishra is a sophomore at Shrewsbury High School. He is pursuing his studies with focus in mathematics and sciences. His project explored organic alternatives to conventional silicon-based solar cells in order to generate environmental friendly, efficient, and cost-effective solar technology. In addition to the CleanTech Award, he also received an award from the US Army at 2009 Worcester Regional Science & Engineering Fair held at WPI for this project.

He is member of his school's Varsity Math Team, Physics, and Latin Clubs where he participates in local, regional, and national competitions, and has earned a silver and a gold medal in the National Latin Examination. In addition to academic achievements, Abhinav has a 1st Degree Black Belt in Karate, and enjoys playing tennis and soccer. He is an accomplished classical vocal singer and harmonium player; he regularly performs in several concerts in New England area and at Boston's Hatch Shell**.** He was recognized by UNICEF for promoting Children Radio Programs. As a leader of HSS Youth Group, he instructs Yoga and is an active member of Ekal Vidyalaya New England Chapter (Single Teacher School) promoting primary education in tribal areas and underprivileged communities in rural India.

MY PROJECT:

For my project I investigated the development and electrical characterization of DSSC prototypes using Nanocrystalline TiO_2 (titanium dioxide) film sensitized by organic anthocyanin dyes, pigments from blackberries and pomegranate juice. The inspiration for this research project came in 2008, as the world devoted more and more of its attention to developing alternative sources of energy and environmentally friendly fuels due to the diminishing reserves and soaring prices of gasoline. Solar energy was considered a strong candidate, since we receive more than enough energy from the sun to power our planet every day. However, there are still several barriers to the widespread adoption of solar technologies. Specifically, conventional silicon solar cells suffer from reduced efficiency at higher

temperatures, output strongly dependent on ambient light intensity, and high production costs. The use of Silicon Chlorosilane for purifying the metallurgical-grade silicon (MG-Si) and doping the silicon with heavy metals such as cadmium, arsenic, indium, and gallium create significant amounts of hazardous byproducts. Some non-silicon (copper indium gallium diselenide or CIGS) cells have higher efficiency because they respond to shorter wavelengths than silicon. However, they are potentially resource-limited as well as pose several environmental concerns similar to silicon solar cells due to the use of toxic gases and chemicals used in their manufacturing processes, e.g. use of arsenides such as GaAs, InAs, and AlGaAs in the doping process.

Interest in the study of organic alternatives, especially dye-sensitized solar cell (DSSC) technology, has grown considerably in recent years to find a material that would collect a wider range of wavelengths and so have increased efficiency, without the drawbacks of CIGS materials.

For developing DSSC prototypes, I used conductive glass plates coated by SnO_2 and deposited a thin film (approx 8-10 um thickness) of Nanocrystalline Titanium Dioxide (TiO_2) in order to create a negative electrode (Cathode). The film is then sensitized by organic anthocyanin dyes made up of blackberries and pomegranate pigments. The positive electrode is created by depositing carbon film on a SnO_2 coated glass plate. The electrical output characteristics of DSSC prototypes were measured, and compared with those of silicon solar cells under different control conditions (i.e. light intensities, temperature). The study showed that at low light intensities the electrical output characteristics of DSSC are comparable with those of silicon cells. The current and power densities (*Id* and *Pd*) increase with the increasing light intensities, suggesting that the electron-injection rate throughout the DSSC prototypes increases with increased absorption of photons by the dye thus proving the working principle. The DSSC cell appears to be less sensitive to light intensity variation, indicating that the pigments are better at capturing photons at all light levels, and the fabrication and assembly processes are relatively simple and inexpensive.

DSSC, in using organic dyes and being recyclable, appear to offer the most attractive alternative organic alternative to the conventional silicon solar cell. The study concluded that the DSSC technology seems to offer a low-cost solar cell solution with significant improvement in price/performance ratio, improved overall efficiency, and minimal environmental impact compared to conventional silicon solar cell. Efforts are currently underway at several research institutions and universities around the world to improve durability and stability of DSSC using gel electrolytes and non-liquid electrolytes. For example, it is observed that the use of iodine/iodide electrolyte affects the durability and manufacturability since the electrolyte acts as an aggressive corrosive agent and leaks out.